NOTES ON ASTEROIDS IN THE BRITISH MUSEUM (NATURAL HISTORY)

2. SOME ASTROPECTINID SPECIES

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(*With Plate* 6)

THE first Note in this series (John, 1948) began with the statement that the Asteroids in the British Museum (Natural History) were being revised. This, the second Note, will be the last in the series by the present author, who has since left the Museum staff. It is shorter than it was intended to be and deals only with the following six Astropectinid species:

Lonchotaster tartareus Sladen.	*Leptychaster antarcticus* Sladen.
Dytaster exilis Sladen.	*Leptychaster kerguelensis* Smith.
Plutonaster agassizii (Verrill).	*Craspidaster hesperus* (Müller & Troschel).

Lonchotaster tartareus Sladen

Lonchotaster tartareus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 104, pl. 16, figs. 1–5.

The only species and the only specimens of the genus *Lonchotaster* remain those described by Sladen in 1889, *L. tartareus* from 2,400 fathoms between the Canaries and the Cape Verde Islands, and *L. forcipifer* from nearly 2,000 fathoms in the Southern and Antarctic Oceans south-west of Australia. The large Astropectinid described by H. L. Clark (1916: 30) as *Lonchotaster magnificus* was referred to *Dipsacaster* by Fisher (1919: 150).

Fisher, both in 1917 (p. 170) and 1919 (p. 150), makes what are, in effect, minor corrections to Sladen's account of *L. tartareus*, saying there is a small spine on each marginal plate and one on most of the actinal intermediate plates; he refers to Sladen's figures as bearing out his statement. As for the superomarginal plates, Fisher is wrong and Sladen's account, with which his plate agrees, is correct: 'within the interbrachial arc and at the base of the rays in the large example, a small conical tubercle is present close to the upper end of the plate, but it is not found in the smaller specimens'. For the inferomarginals neither Sladen's account nor Fisher's is quite correct. In the larger specimens there are small spines, of diminishing size, as far out as about the thirtieth plate, but not beyond; they are present on the plates of the interbrachial arc of one of the smaller, entirely absent from the other.

Sladen's account of the spination of the actinal intermediate plates is correct, including the implication that there are no spines on those of the smaller specimens.

Dytaster exilis Sladen

Dytaster exilis Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30** : 65, pl. 2, figs. 3 & 4 ; pl. 4, figs. 9 & 10 (figs. of var. *gracilis*) ; Wood-Mason & Alcock, 1891 : 429 ; Alcock, 1893 : 80.

The *Challenger* took the type of *D. exilis* off Valparaiso in the Pacific, those of its varieties *gracilis* and *carinata* in the Atlantic near Tristan da Cunha and off the Maryland coast of N. America respectively. The only subsequent records are those of *exilis* itself by Wood-Mason and Alcock from the Bay of Bengal, where it 'has several times been met with . . . between 1748 and 1924 fathoms on globigerina ooze'. They did not describe their specimens beyond giving the colour when fresh as salmon-pink.

One of their specimens, from St. 117, 1,748 fms., is in the British Museum. It is dry and small: $R = 47$ mm., $r = 9$ mm., $R : r$ is 5·2. The abactinal paxillae have four to ten finely thorny spinelets; there are no pedicellariae among them. The superomarginals number thirty-three. They are not confined to the lateral wall but encroach a little on the abactinal surface; those in the inter-brachial angle do so to the extent of 1 mm. This is a marked difference to the type of *exilis*; in the variety *gracilis*, on the other hand, they do encroach abactinally though not so strongly as in this specimen. When seen from the side the length of the plates is less than the height in the inter-brachial angle, greater than it in mid-arm, equal to it at the end of the arm. The large spines are missing from the plates at the ends of the arms which are abraded, but I am unable to say if they have merely been rubbed off.

The inferomarginals correspond to and are of the same size as the superomarginals as seen from the side. On the actinal surface their breadth is greater than their length on the inner part of the ray. In the interbrachial angle some of the marginal plates of both series carry two spines.

The enlarged spine on the adambulacral plate first appears about half-way down the arm and arises more often from the second than the first comb of spines. The latter has ten, the former eight, spines, and they are followed by a third row as Sladen describes for *exilis*. The actinal intermediate plates extend to about the third inferomarginal. Each bears a group of widely spaced spines, up to fourteen on the largest. They and the spines of the marginal and adambulacral plates are finely thorny.

The madreporite is neither large nor conspicuous.

In the shape of the superomarginal plates, the absence of pedicellariae, and the occurrence of the enlarged spine on the adambulacral plates I see this specimen as nearer to the var. *gracilis* than to *exilis* itself. Experience with other species leads me to believe it possible that more specimens may serve to bridge the gap which now appears to exist.

Verrill (1895 : 131) was not able to satisfy himself that *D. exilis* var. *carinata* was distinct from the young of his *D. grandis* (of which *D. madreporifer* Sladen is a synonym). A direct comparison leaves no doubt of its distinctness. In the first place the larger specimen described by Sladen cannot be regarded as young, having $R =$ 98 mm. The paxillae of its disk are comparatively large, those of *grandis* conspicuously small; the pedicellariae on the actinal intermediate plates of *carinata* are larger and of valves more highly modified than those of *grandis* (Plate 6, fig. 1); the adambulacral armature differs, for whereas *grandis* has only one row of strong furrow spines, *carinata* has two, the second being of the peculiar dagger-like form described by Sladen. Finally, the appearance of the two forms is quite different to the naked eye for, whereas *D. grandis* is distinguished by the strong high sides which the marginals give to its rays, in the var. *carinata* the marginals are comparatively poorly developed, their combined height being only a little more than half that of *grandis*, and the spines are correspondingly smaller (Plate 6, figs. 2 & 3).

Plutonaster agassizii (Verrill)

Archaster agassizii Verrill, 1880, *Amer. J. Sci.* **20**: 403.
Plutonaster rigidus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 91, pl. 14, figs. 3 & 4; pl. 15, figs. 3 & 4; Koehler, 1909: 19, pl. 4, fig. 6; pl. 10, figs. 5 & 6.
Plutonaster rigidus var. *semiarmata* Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 94, pl. 14, fig. 5.
Plutonaster agassizii Verrill, 1894, *Proc. U.S. Nat. Mus.* **17**: 248; 1895: 131; 1899: 211, pl. 27, fig. 6.

Verrill (1880: 403) in his 'Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England' described the new species *Archaster agassizii*. Sladen (1889) made no reference to Verrill's paper in the *Challenger* Report. In 1894 (p. 248) Verrill placed his species in Sladen's genus *Plutonaster*; listed Sladen's *rigidus* and *rigidus* var. *semiarmata* and a part of his *bifrons*, all from off the coast of North America, as synonyms; and added to the description. In 1899 he described the species as occasionally having pedicellariae and gave a figure showing one.

Koehler (1909: 19) used Sladen's name, *rigidus*, for describing a series taken in mid-Atlantic in the latitude of the Azores, explaining that he did so because he could not be sure that Verrill's *agassizii* and Sladen's *rigidus* were the same. He found Verrill's description inadequate and his attempt to have photographs of his specimens compared with Verrill's had failed.

Dr. Austin Hobart Clark has generously made it possible for me to make the sort of comparison that Koehler wished to make by sending me six specimens of Verrill's species. They came from off New Jersey, 39° 58′ 30″ N., 70° 30′ 00″ W., 384 fms.

They show that *agassizii* and *rigidus* are one. Koehler had found that the var. *semiarmata* of Sladen could not be maintained, so variable is the occurrence of spines on the inferomarginal plates. Verrill (1894: 248) says that there may be all gradations from those having no marginal spines whatever to those that have a large spine on nearly every marginal plate of both series. Koehler does not record spines on the superomarginal plates and it may be assumed that they were not present in his specimens. There is none in the six specimens from Verrill before me, but in the type of Sladen's *rigidus* there is on one or two plates a single slightly enlarged granule such as I have seen to occupy a similar position from which a spine often arises in other asteroids.

Koehler makes no mention of pedicellariae. I find a row of four to be present actinally in the midline of one interradius of one of Verrill's specimens, and a single one in another interradius. They have four or five blades. The type of *rigidus* has some small groups of spines in the actinal intermediate areas which are pedicellaria-like in their disposition, but the 'blades' are short and coarse.

Sladen (p. 92) described the conical spinelet immediately behind the furrow spines on the outer adambulacral plates. Though Koehler did not mention it, it is to be assumed it was present since he identified his specimens with Sladen's species. It is present in Verrill's specimens, more strongly developed in some than in others.

$R : r$ is more than 3 in one of Verrill's specimens ($R = 49$ mm., $r = 15$ mm.); it is less than 3 in the remaining five in which R varies from 42 to 63 mm. and r from 17 to 22 mm.

Verrill included the small specimen which Sladen (p. 88) described with a query as *P. bifrons* in his synonymy of *agassizii*. It possesses a spine on each marginal plate, inferior and superior; there is a large spine behind the furrow series on each adambulacral plate. In view of its origin it is probably the young of *agassizii*, but it cannot be said with certainty that it is.[1]

Leptychaster antarcticus Sladen and ***L. kerguelensis*** Smith

Leptychaster antarcticus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30** : 190, pl. 31, figs. 3 & 4; pl. 32, figs. 7 & 8.
Leptychaster kerguelensis Smith, 1876, *Ann. Mag. Nat. Hist.* **17** : 110.

The type of *L. antarcticus*, and a second and smaller specimen taken with it ($R = 10{\cdot}5$ mm., $r = 4{\cdot}5$ mm.), are in the Museum collection. They are the only specimens recorded. Bell (1908: 9) thought them the young of *kerguelensis*, but he gave no good reasons for doing so.

Koehler (1917: 53) discussed the question and Fisher (1940: 83) referred to it, but, while not affirming that Bell was wrong, neither accepted his conclusion. It seemed well that I, with access to the types of both species, should re-examine them and other available specimens and report what I find.

The paxillae of the greater part of the swollen abactinal surface of the type of *antarcticus* have lost their spines. It may have happened during transport to and from a safe place in the Second World War. They appear to have been present when the *Challenger* figure (pl. 31, fig. 3) was made. While Sladen's written description is of his usual excellence, fig. 4, pl. 31, is a poor representation: it is, indeed, a misrepresentation of the mouth plates, which are as Sladen describes them in words. It is hoped that the photograph given here conveys a better idea (Plate 6, fig. 4).

Sladen's description of *kerguelensis* is of a large specimen of $R = 66$ mm.; though he listed smaller specimens and gave their sizes he did not otherwise describe them. He states (p. 192) that *kerguelensis* is distinguished from *antarcticus* by the longer and more cylindrically rounded rays, by the larger and more compact paxillae, by the smaller actinal intermediate areas, and, above all, by the characteristic adambulacral armature.

The smallest specimen of *kerguelensis* in the collection was taken with three larger

[1] A doubt is possible about its origin. On p. 87 Sladen gives it as St. 47, off the coast of N. America. On p. 88 he gives St. 47*a*. There was no *Challenger* station of that number but there was one by the *Porcupine* and it was in the Faroe Channel.

specimens (R up to 60 mm.) in 50 fms., off Marion Is. In it $R = 13{\cdot}8$ mm. and $r = 5$ mm., so that it is slightly smaller than the type of *antarcticus* ($R = 15$ mm., $r = 6$ mm.). A direct comparison has been made between them. The rays of the *kerguelensis* specimen are, in proportion, longer and more rounded, and the actinal intermediate areas are smaller; and the differences in proportion give a different facies to each specimen.

But the paxillae are similar in the two specimens and as Sladen described them for *antarcticus*, though his figure is not very good. It is, however, far better than is that of the paxillae of *kerguelensis* (pl. 32, fig. 1). In only three of the fifteen Museum specimens are they as shown in that figure, with the spines represented by low rounded granules, tending to be polygonal where crowded. In the others they are much more spine-like and radiate apart. Though it is not necessarily the biggest specimens in which the paxillae spines are lowest and most crowded, it is in the smallest that they are most spine-like. In short, the distinction between *kerguelensis* and *antarcticus* based upon the nature of their paxillae appears not to be real.

The question of the adambulacral armature remains. It can only be said that Sladen's descriptions are correct and that his figs. 2 & 8, pl. 32, are good representations. It may be added that Koehler's eight specimens of *kerguelensis* conformed with Sladen's description for that species, and that it is implicit in Fisher's account that his three specimens also did so.

And so, since no intermediate stages have been found, it seems best to go on regarding *kerguelensis* and *antarcticus* as distinct species distinguished by their different adambulacral armature.

The three starfishes from the Cape which Bell (1905: 242) recorded as *L. kerguelensis* are *Dipsacaster sladeni* Alcock, as Mortensen (1933: 237) pointed out. Bell (1908: 9) also recorded the species from the Ross Sea, including one specimen in which $R =$ 212 mm. I cannot find that specimen; nor are there any Ross Sea specimens labelled *L. kerguelensis*. There are several jars labelled by Bell '*Leptychaster* young' or 'very young', and I suppose them to be the young examples to which he referred. They are, however, not *Leptychaster* but *Odontaster*—and some other genera are included.

Craspidaster hesperus (Müller & Troschel)

Archaster hesperus Müller & Troschel, 1840, *Ber. preuss. akad. Wiss.*: 104.
Craspidaster hesperus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 177, pl. 17, figs. 5–7; pl. 18, figs. 1–4; Döderlein, 1921: 5 (for synonymy), 8, pl. 1, figs. 2–3.
Craspidaster glauconotus Bedford, 1900, *Proc. Zool. Soc. Lond.*: 290, pl. 24, figs. 8*a*, *b*; Döderlein, 1921: 8, pl. 1, figs. 4–6.
Craspidaster hesperus crassus Döderlein, 1921, *Siboga Exped.* Monog. **46 i**: 9, pl. 1, figs. 1 & 1*a*.

There are in the British Museum thirty-nine specimens. One is from an unknown locality, five are said to be from Japan but there can be no certainty of it, twenty-one from the Chusan Archipelago, one from Amoy, and another from Hong Kong (*Challenger*), two each from the Philippines (*Challenger*) and Batavia, and six specimens of Bedford's *glauconotus* from Malacca.

Döderlein had twelve specimens and took into account, for measurements, &c., three more. He recognized three sub-species differing from one another in the length and width of the arm, the number, size, and spination of the marginal plates, and the number and nature of the actinal intermediate plates. Four of his specimens were from China and Japan, the remainder from East Indian or Malayan seas. The former had shorter and wider arms, and larger and—on the whole, and especially in the second row—fewer actinal intermediate plates. One of the Chinese specimens of unusually plump form, with massive marginals and having only one row of actinal intermediate plates, he made the type of a new sub-species, *crassus*; the remainder he regarded as typical *hesperus*. The Malayan examples, with longer more slender arms, more numerous marginals, smaller and more actinal intermediate plates—especially in the second row—and with, in the larger, spines on the ventral faces of the inferomarginals, he grouped with Bedford's specimens in the sub-species *glauconotus*.

The present collection bears out Döderlein's conclusions concerning the relation of $R : r$, and the number of marginal plates. In the twenty-one Chusan specimens R ranges from 8·5 to 42 mm. and the relation $R : r$ varies from 2·1 in the smaller to 3·5 in the larger. In the six specimens of *glauconotus* from Malacca the range of R is 18 to 67 mm. and of $R : r$ 3·2 to 4·6. There is no doubt that the latter are conspicuously longer-armed. They have, too, a larger number of superomarginal plates. Perhaps the most telling way of making a difficult comparison is to bring together (1) a number of specimens of roughly equal sizes, as follows:

Locality	*R in mm.*	*R : r*	*No. of marginals*
? Japan	34	3·2	24
Chusan	29·5	3·1	23
Timor (Döderlein) . .	29	3·6	26
Malacca (*glauconotus*) . .	31	4·4	33

and (2) a number of specimens with roughly equal numbers of marginal plates:

Locality	*No. of marginals*	*R*	*R : r*
? Japan	27	41	3·4
Chusan	30	42	3·5
Hong Kong . . .	31	53	3·6
Philippines	31	37·5	3·8
Malacca (*glauconotus*) . .	33	31	4·4

The first list shows that Bedford's *glauconotus* is sharply marked off from the other specimens by the high value of $R : r$ and by the large number of marginal plates; the second, that a specimen of *glauconotus* with a given number of marginals is of much smaller major radius and has a markedly higher value of $R : r$ than specimens of *hesperus* with the same number of marginals.[1] Each list tells the same story, but by means of different specimens.

One of the Batavia specimens is roughly equal in size ($R = 57$ mm.) to one of those from Malacca ($R = 59$ mm.). $R : r$ is 4 in the former, 4·3 in the latter, and the relative numbers of marginal plates are 40 and 47.

[1] The large major radius of the Hong Kong (*Challenger*) specimen is because of its peculiarly massive marginals; compare the type of *crassus* which, with only 20–22 marginals, has $R = 46$ mm.

The spines on the lower surfaces of the inferomarginal plates and on the actinal intermediate plates afford a strong difference between Bedford's *glauconotus* and typical *hesperus*. They are well developed on each of the six specimens. They occur, strongly on the inferomarginal plates, poorly developed on the actinal intermediate plates, of the larger specimen ($R = 57$ mm.) from Batavia; there are traces of them on the actinal-intermediate plates only of the second Batavian specimen ($R = 57$ mm.). There are spines, varying in number but never numerous, on the lower surfaces of the inferomarginals of (1) the *Challenger* specimen from Hong Kong (an odd one or two), (2) the larger *Challenger* specimen from the Philippines (one on each of two rays), and (3) one of the Japan specimens (one on each of the first eight plates).

I find nothing to support Döderlein's implication that there is a real difference in the number of actinal intermediate plates of 'Chinese' and 'Malayan' specimens. He gives as a characteristic of some of the former that they have few and massive plates, sometimes only one row (var. *crassus*). It is true that in the British Museum collection six of the smaller specimens from Chusan ($R = 10$–17 mm.) have only one row, but since the remaining and larger specimens have two rows, and the largest specimens have the highest number of plates, this is clearly a matter of growth. The only other specimens with no second row of actinal intermediate plates are (1) one of *glauconotus* of no less than $R = 60$ mm. (no second row in two interradii; a single plate comprises the 'second row' in each of the other three); (2) the smallest specimen of *glauconotus* ($R = 18$ mm.); (3) Sladen's 'young phase' ($R = 22$ mm.) from the Philippine Islands. The largest *glauconotus* ($R = 67$ mm.) has six to eight plates in the first, three plates in the second, row. The specimen from an unknown locality is exceptional: it has $R =$ only 31 mm. and yet has seven to eight plates in the first row, three to four in the second, and it possesses a third row of one plate on either side.

Sladen described the occurrence of a thumb-like spine on the aboral margin of the adambulacral plates of his Hong Kong specimen and its absence from those from the Philippines. It was not present in the specimens from the Philippines seen by Fisher (1919: 60). Döderlein does not mention it.[1] It is (as Bedford says) present in *glauconotus*; I find it in each specimen from the smallest ($R = 18$ mm.) to the largest ($R = 67$ mm.). It is present in the specimen from an unknown locality and in that from Amoy, in three of those from Japan ($R = 35$–41 mm.), but it is absent from all but a few plates of the fourth ($R = 34$ mm.). It is not present in the two specimens from Batavia. It is absent from twenty of the twenty-one specimens from Chusan of $R = 8{\cdot}5$ to $29{\cdot}5$ mm., but is present in the twenty-first which is conspicuously larger having $R = 42$ mm.

The conclusion appears to be that in the present state of our knowledge *glauconotus* should continue to rank as a sub-species distinguished by the length of its rays, the number of its marginals, and the presence of spines on the inferomarginal and actinal intermediate plates; but that *crassus* cannot be maintained. The species is seen to be variable: e.g. the Hong Kong specimen approaches Döderlein's *crassus* in its massive marginals and yet bears traces of spines, a *glauconotus* character, on some of them; the thumb-like spine of the adambulacral plate is absent from most small

[1] His fig. 6*a* on pl. 1 shows it to have been absent from his specimen from Lombok. Text-fig. 1 and the accompanying text do not make clear the possibility of its existence.

specimens but it is present in one *glauconotus*, $R = 18$ mm., and it may be entirely wanting on large specimens up to $R = 57$ mm.

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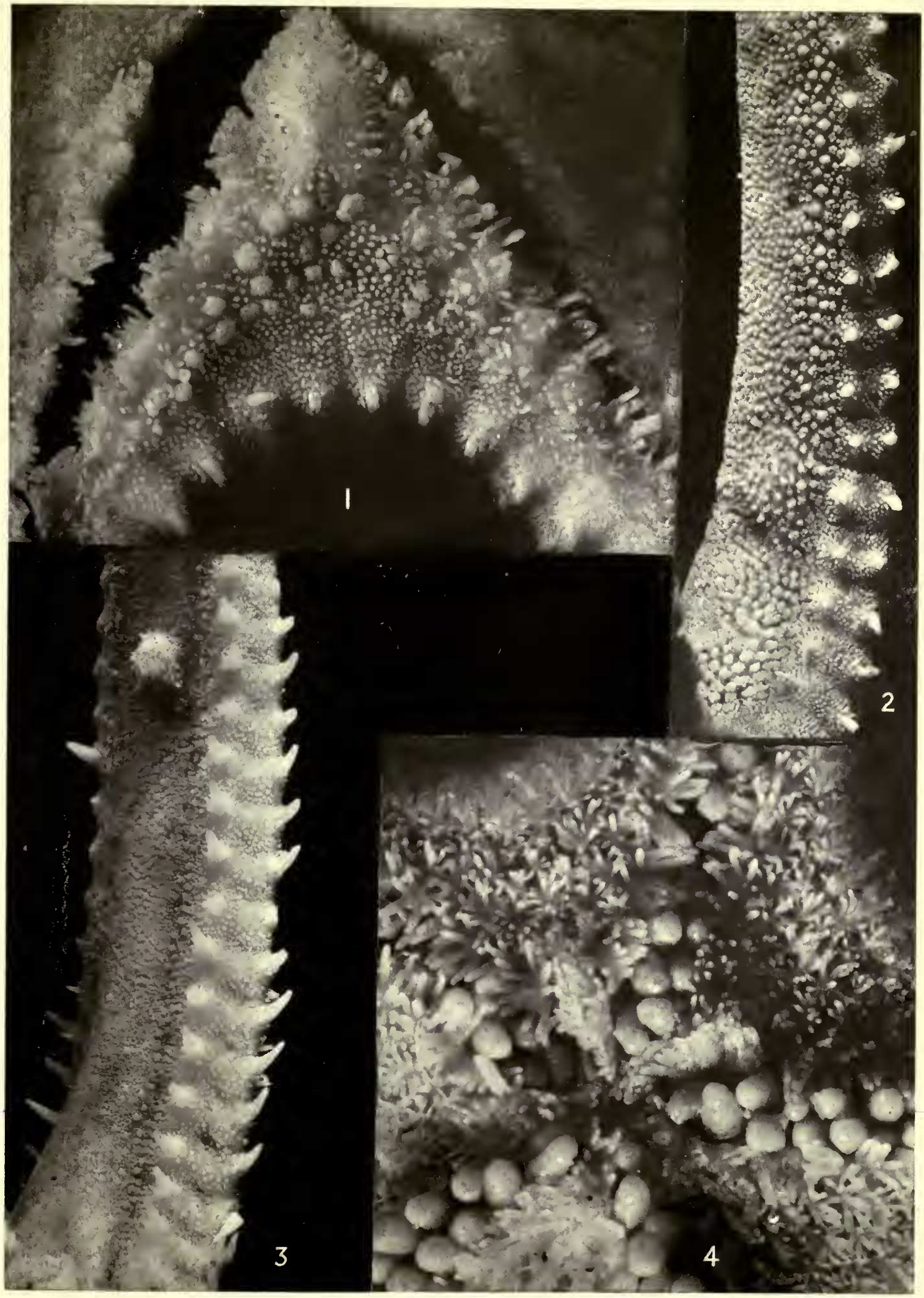
PLATE 6

FIG. 1. *Dytaster exilis* var. *carinata*, type, mouth-angle and actinal-intermediate area, × 5.

FIG. 2. *Dytaster exilis* var. *carinata*, type, side view of the proximal portion of arm, × 4.

FIG. 3. *Dytaster grandis*, cotype, side view of proximal portion of arm, × 4.

FIG. 4. *Leptychaster antarcticus*, type, under surface of disk, × 10.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LERNAEODISCUS PUSILLUS NOV. SPEC., A RHIZOCEPHALAN PARASITE OF A *PORCELLANA* FROM EGYPT

By HILBRAND BOSCHMA

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IN 1936 Dr. Isabella Gordon kindly sent me twelve specimens of Rhizocephalan parasites on Porcelain Crabs collected by Dr. R. Gurney in coral rock on the Harbour Reef near Ghardaqa, Red Sea, Egypt. The hosts of these parasites were provisionally identified as *Porcellana serratifrons* of Nobile, *nec* Stimpson. The parasites appear to represent a hitherto undescribed species.

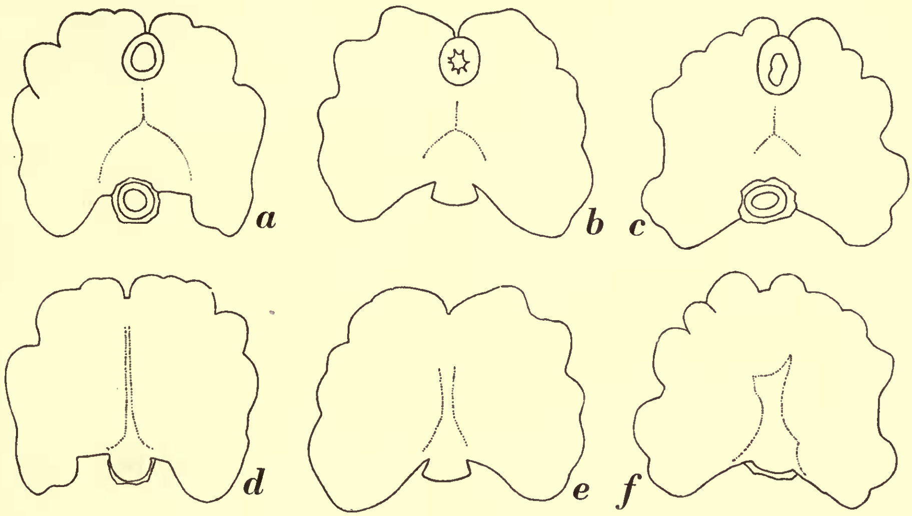

FIG. 1. *Lernaeodiscus pusillus*: *a–c*, dorsal view of three specimens, mantle opening in the upper part, stalk in the lower part of the figures; *d–f*, ventral view of the same specimens. ×18.

The animals are of very small size, their greatest diameter being about 2 mm., their antero-posterior diameter (in the median plane) about 1½ mm., and their smallest (dorso-ventral) diameter less than 1 mm. The total diameter in the antero-posterior direction is, as a rule, slightly less than the greatest diameter. The outlines of three specimens in dorsal view are given in Fig. 1*a–c*, in ventral view in Fig. 1*d–f*. The shape of the parasites is more or less roundish or somewhat trapezoid or triangular; their contour is slightly irregular as the mantle shows a number of rather inconspicuous lappets. The comparatively wide mantle opening, which is surrounded by a well-developed muscular wall, is found on the anterior region of the dorsal surface. As a rule the dorsal surface shows a system of three shallow grooves running from

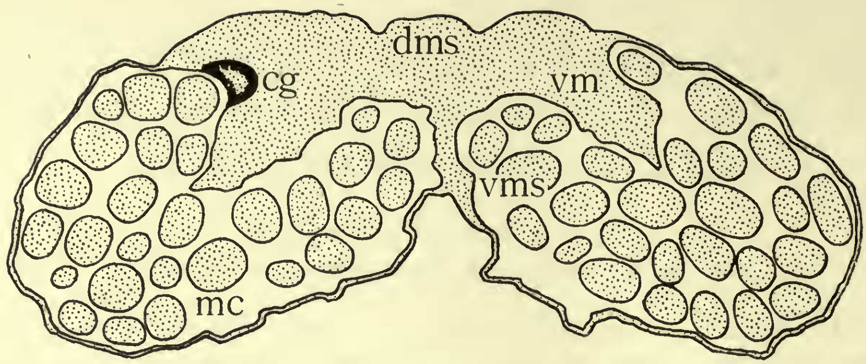

FIG. 2. *Lernaeodiscus pusillus*, specimen of Fig. 1*a*, *d*. Transverse section showing one of the colleteric glands (*cg*). *dms*, dorsal mesentery; *mc*, mantle cavity; *vm*, visceral mass; *vms*, ventral mesentery. ×60.

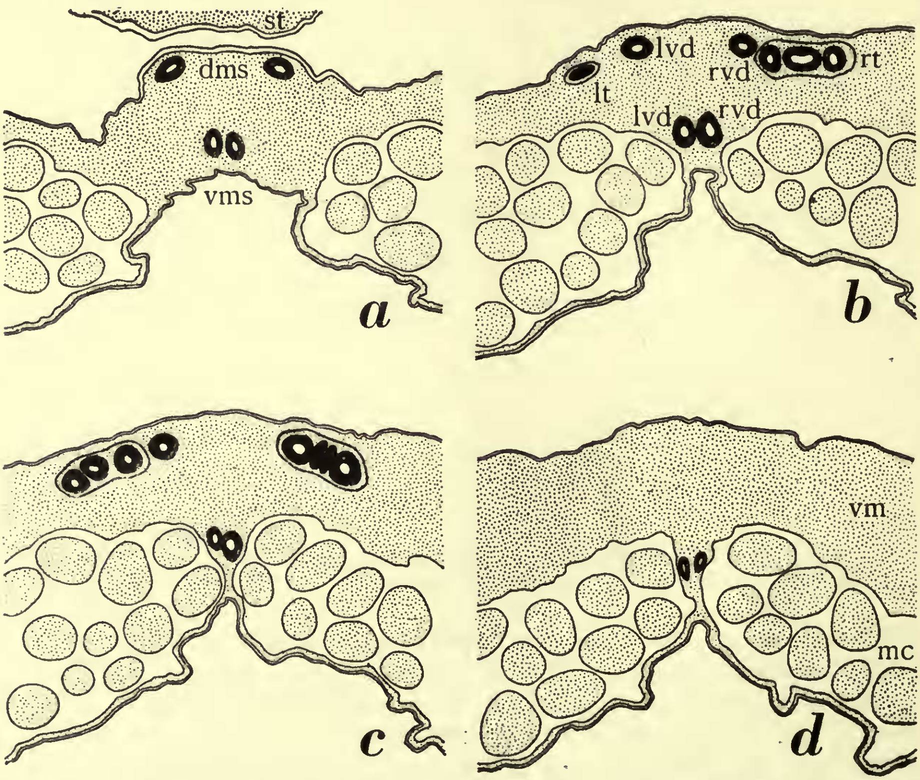

FIG. 3. *Lernaeodiscus pusillus*, specimen of Fig. 1*a*, *d*. Central parts of transverse sections, *a* from a region not far from the stalk, each following section from a more anterior region. *dms*, dorsal mesentery; *lt*, left testis; *lvd*, left vas deferens; *mc*, mantle cavity; *rt*, right testis; *rvd*, right vas deferens; *st*, stalk; *vm*, visceral mass; *vms*, ventral mesentery. ×64.

the centre to the mantle opening and to the lateral parts of the posterior region of the body. On the ventral surface there is a distinct groove running from the stalk in an anterior direction; this groove varies in length and in breadth.

The three specimens shown in Fig. 1 were sectioned transversely for the study of their internal structure. In sections from the region about half-way between the stalk and the mantle opening the colleteric glands are found; as a rule one of these is situated more anteriorly than the other. These glands (Fig. 2, *cg*) are more or less cup-shaped small cavities surrounded by an epithelium with a stronger affinity for stains than the surrounding parts. The figure further shows that the dorsal surface of the visceral mass is broadly attached to the mantle, in this way forming the so-called dorsal mesentery. On the other side the visceral mass is connected with the mantle by means of a real mesentery, the ventral mesentery. Where the latter is attached to the mantle there is, externally, the longitudinal groove referred to above.

In the three sectioned specimens the colleteric glands entirely agree with one another in shape, their position in the visceral mass, and their size. The male organs in two of the sectioned specimens are also similar in every respect (Fig. 3), but in the third specimen (Fig. 4) they are slightly more complicated.

The male organs closely correspond with those of *Lernaeodiscus okadai* Boschma (cf. van Baal, 1937, figs. 18–21). The male openings, in a region about half-way between the stalk and the mantle opening, are found on each side of the ventral mesentery (Fig. 4*d*, *e*). The vasa deferentia run along the ventral mesentery until they reach the posterior part of the visceral mass. Here they turn towards the dorsal surface (Figs. 3*a*, 4*a*), and continue their course along the dorsal mesentery in an anterior direction. After the vasa deferentia have passed into the testes the latter extend in a lateral direction, so that the terminal part of the testes is the most lateral part of the male organs (Fig. 3*b*, *c*).

As remarked above, the male organs in two of the sectioned specimens have a similar shape (as represented in Fig. 3); in the third specimen the male organs show some differences. Here the left testis (Fig. 4*d*, *e*) does not extend in a lateral direction, whilst the terminal part of the right testis after continuing its course in a lateral direction towards the right margin of the visceral mass (*a* in Fig. 4) obtains a curved shape by extending towards the median plane again (*p* in Fig. 4). The closed end of this testis consequently lies next to the right vas deferens (Fig. 4*b*).

Besides having a course in a lateral direction the testes in all the three specimens are strongly contorted, so that in sections they appear to be divided into numerous smaller parts.

It is rather difficult to define the characters by which *Lernaeodiscus pusillus* can be distinguished from the other species of the genus that are, like the new species, parasites of Porcelain Crabs, viz. *L. porcellanae* Müller (cf. Müller, 1862; Boschma, 1931) and *L. okadai* Boschma (cf. Boschma, 1935; van Baal, 1937).

The external shape of *Lernaeodiscus porcellanae* seems to be rather constant, the animal having well-developed lappet-like expansions of the mantle. But too few specimens are known to establish this peculiarity as a constant character for full-grown as well as immature specimens. In *L. okadai*, van Baal (1937) has shown that the external shape is subject to a very large amount of variation. Here, as a rule,

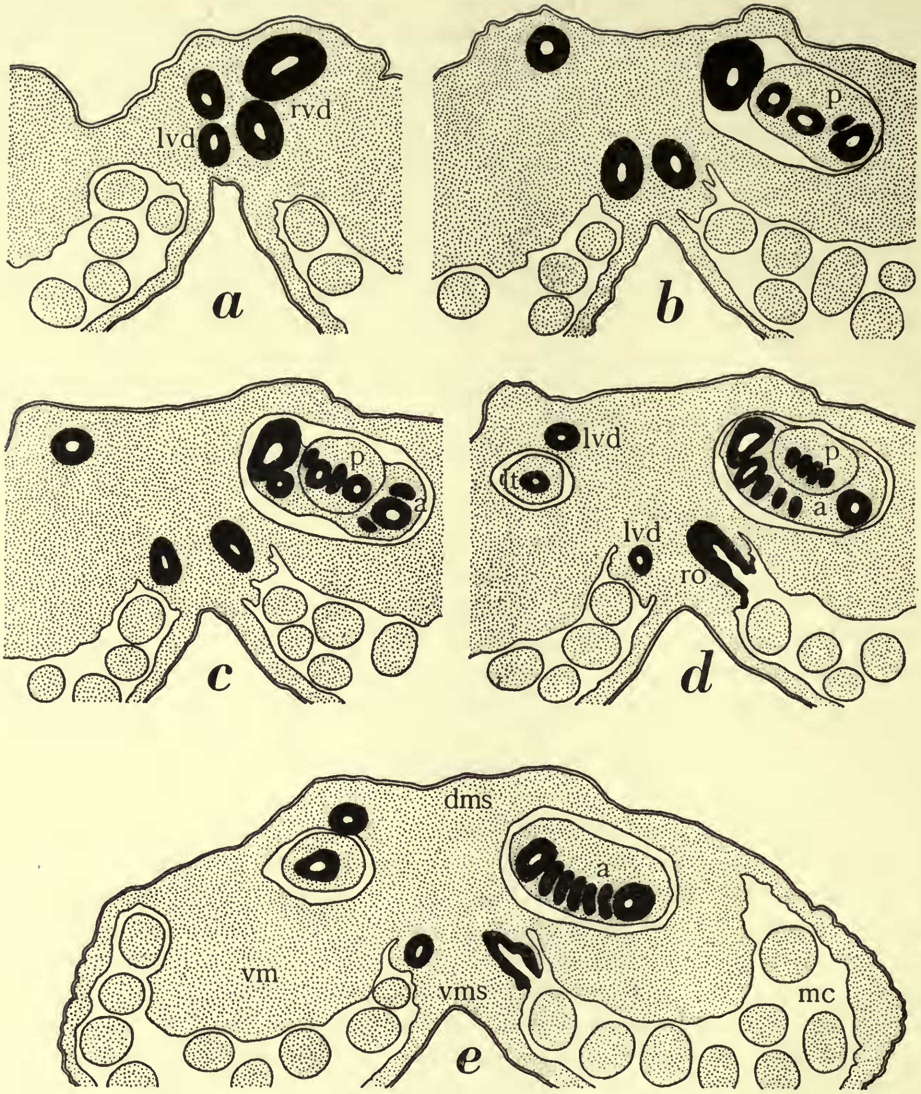

FIG. 4. *Lernaeodiscus pusillus*, specimen of Fig. 1*c*, *f*. Central parts of transverse sections, *a* from a region not far from the stalk, each following section from a more anterior region. *a*, anterior part of right testis; *dms*, dorsal mesentery; *lt*, left testis; *lvd*, left vas deferens; *mc*, mantle cavity; *p*, posterior part of right testis; *ro*, right male genital opening; *rvd*, right vas deferens; *vm*, visceral mass; *vms*, ventral mesentery. ×64.

the lappets do not occur in young specimens but are generally distinct in mature animals. The specimens of *L. pusillus* have, as far as their external shape is concerned, a rather constant appearance.

The colleteric glands in the genus *Lernaeodiscus* are of such a simple structure that they cannot furnish characters for specific distinction.

The male genital organs are, to a large degree, subject to individual variation, as is evident from van Baal's (1937) elaborate researches on numerous specimens of *L. okadai*.

The only remaining distinctive character is that of the size of the animals. On this character *L. porcellanae*, by its comparatively large size, is at once distinguished from *L. okadai* and *L. pusillus*. In *L. pusillus* the greatest diameter is about 2 mm., and the total length is but slightly smaller. The sectioned specimens are fully mature, as their mantle cavities contain large quantities of eggs. For *L. okadai* there are the following data (the numbers giving the length and the greatest transverse diameter in mm.) recorded by van Baal (1937):

$2\frac{1}{2}\times 3$ (small number of eggs); $4\times 5\frac{1}{2}$ (no eggs); $4\frac{1}{2}\times 5$ (small number of eggs); 4×5 (large number of eggs); $2\frac{3}{4}\times 3\frac{1}{2}$ (very small number of eggs); $1\frac{1}{2}\times 2$ (no eggs); $6\times 7\frac{1}{2}$ (large number of eggs); $3\frac{1}{2}\times 5\frac{1}{2}$ (no eggs); $2\times 4\frac{1}{2}$ (many eggs); $2\frac{1}{2}\times 4$ (crowded with eggs); $5\frac{1}{2}\times 6$ (many eggs); $4\frac{1}{2}\times 6$ (many eggs); $4\times 4\frac{1}{2}$ (many eggs); $2\frac{1}{2}\times 4$ (without eggs).

These data show that the specimens with numerous eggs are the larger ones in which at least one dimension reaches 4 mm. Moreover, when in large specimens no eggs are present in the mantle cavity they may have been recently discharged from this cavity. The data, therefore, give sufficient evidence for the opinion that *L. okadai* reaches its mature state at a stage in which at least in one dimension the body has a size of 4 mm. On the other hand, *L. pusillus* is fully mature at a size of 2 mm.

Summarizing it may be remarked that though the specific characters of *Lernaeodiscus pusillus* may appear unconvincing there is sufficient evidence for regarding the parasite as specifically distinct from the other forms belonging to the genus.

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ON A RARE DEEP-SEA FISH *NOTACANTHUS PHASGANORUS* GOODE (HETEROMI-NOTACANTHIDAE) FROM THE ARCTIC BEAR ISLE FISHING-GROUNDS

By DENYS W. TUCKER, B.Sc.
(BRITISH MUSEUM (NATURAL HISTORY))

and

J. W. JONES, Ph.D.
(UNIVERSITY OF LIVERPOOL)

(*With Plates 7–9*)

INTRODUCTION

On the 27th of August 1949 the Fleetwood trawler *Wyre General* landed an unusual fish from the Bear Isle grounds. No information is available concerning the depth at which it was taken, but about 100 fathoms may be assumed from our knowledge of the fishery. Messrs. James Mitchell (Port Health Officer) and P. J. Fisher (Chief Sanitary Inspector), who have frequently been instrumental in obtaining rare fishes, kindly forwarded it to the Department of Zoology, University of Liverpool, where it was recognized as a rare *Notacanthus* and presented to the British Museum. The species is *N. phasganorus* Goode, new to the national collections. Only five other authenticated specimens are known, all in American museums, and of these but two have been described and figured.[1]

The holotype (U.S. National Museum, Washington, No. 25972; Goode (1881); Goode & Bean (1894 = 1896)) was taken from the stomach of a Ground-shark, *Somniosus brevipinna* Lesueur = *S. microcephalus* (Bloch & Schneider), on the Grand Bank of Newfoundland, and was partly digested and mutilated about the head. Bigelow & Schroeder (1935) describe a specimen trawled in about 100 fathoms, 20 miles south of Sable Island, which was in good condition except that the viscera had been removed, and the same authors mention a further example from the same locality (Museum of Comparative Zoology, Cambridge, Mass., Nos. 33946 and 35306 respectively).

[1] A large and originally well-preserved *Notacanthus* obtained in Iceland during the voyage of *La Recherche* and figured as *N. nasus* Bloch by Gaimard (1851, pl. XI) and by Cuvier (1836, pl. 55) has been tentatively referred to *N. phasganorus* Goode by Vaillant (1888*b*), who was able to examine the specimen (Musée National d'Histoire Naturelle, Paris, No. A. 6864). One of us (D.W.T.) visiting Paris in October 1950 was told by Prof. L. Bertin that it could not then be found. 'Très probablement a-t-il été détruit à une date ancienne (vers 1889)'. We have little doubt concerning the accuracy of Vaillant's identification, but do not regard the published figures and data available as sufficiently reliable for a critical determination. See Saemundsson (1949) for further discussion and a bibliography of Icelandic material.

In reply to a request for further information on his material Dr. William C. Schroeder disclosed that two more examples have since been taken: M.C.Z. No. 37027 in 420 fathoms at 42° 18′ N., 65° 01′ W., and No. 37037 in 100 fathoms at 44° N., 57° W. Dr. Schroeder is preparing a paper on the species in which these will be described and has kindly allowed us to use such unpublished data as are needed to establish the identity of the Bear Island specimen. We wish also to acknowledge the assistance of Mr. Ernest A. Lachner of the U.S. National Museum who re-examined the holotype for us. The illustrations to the present paper are (with the exception of Fig. 1) the work of Mr. Hubert Williams and the X-ray photographs were taken by Mr. P. E. Purves.

Modern papers by Matsubara (1938) on his *Notacanthus fascidens* and by Trotti (1939) on *N. bonapartei* Risso (based on the examination of 9 and 69 specimens respectively) have largely invalidated the taxonomic distinctions made by earlier workers, especially by Goode & Bean. Matsubara concludes:

'Among the characteristics used in the taxonomy of the fishes of the family Notacanthidae, the number of anal spines and the positions of the insertions and also end points of the fins, which are in reality most variable, are considered to be of most importance. . . .It would be superfluous to say that one must re-examine whether or not each known species belonging to the Notacanthidae is an independent species by taking the above mentioned variabilities into consideration.'

Trotti remarks similarly:

'Concludendo, la grande variabilità del profilo del muso e soprattutto la mancanza di persistenza del rapporto tra dorsali ed anali dure . . . ci porta ad una revisione dei caratteri differenziali dei rappresentanti del genere *Notacanthus* e *Gigliolia*.'

In publishing this full account of the new specimen (British Museum (Natural History), No. 1950.3.30.2) we hope to put on record material of value to such a subsequent revision, and to justify an identification which not only extends the known range of *N. phasganorus* from the western Atlantic to the Arctic but also provides the first published data on the bionomics of the species if not of the genus. But although we now identify our specimen with Goode's species, we are conscious that in the present state of the taxonomy of the genus this name may not be final. There is need of a critical re-examination especially of the material designated *N. chemnitzii* Bloch 1787, *N. nasus* Bloch 1795, *N. phasganorus* Goode 1881, and *N. analis* Gill 1883, the inter-specific differences between which, as at present described, do not seem greater than the intra-specific variation demonstrated elsewhere by Matsubara and by Trotti. It is probable that such a re-examination of the types of these four 'species' supplemented by observations from other material will confirm our suspicion that some or all may be identical. This is no new speculation (see, for example, Lütken, 1898), and it may reasonably be inquired why no precise solution has yet been given. The answer is that apart from the comparative paucity of material, aggravated by its wide dispersal in study-collections, even the type-locality of Bloch's material is not certainly established—though stated by him to have come from the East Indies it has since been believed to have come from Iceland—and the originally bad condition of the holotype has since further deteriorated. (Cf. accounts of Bloch himself, of Cuvier &

Valenciennes (1831), and of Hilgendorf in Goode & Bean (1896).) Even if the specimen in the Berlin Museum is still in existence, it is therefore exceedingly doubtful whether it retains characters adequate for a modern redescription of Bloch's species.

We have no more material relevant to that problem in the British Museum (Natural History), but hope in a subsequent paper to redescribe the types of *N. sexspinis* Richardson 1844 and *N. annectens* Boulenger 1904, and to give accounts of the series of these and related species in our collections as a contribution towards a future full revision. A forthcoming report on the Notacanthidae collected by the Danish *Thor* Expeditions in the north-eastern Atlantic will provide further material.

DESCRIPTION

Although the body is very well preserved, three factors seriously complicate the usual table of measurements. Firstly the fish is a spawning female, greatly distended by a mass of ripe eggs: as a consequence the vent is widely dilated, blocked by a large plug of ova, and opens posteriorly rather than ventrally, while the postero-lateral walls of the abdomen project as a pair of pouches which partly embrace the vent and conceal the origin of the spinous anal fin. This general distortion of the abdomen renders measurements of body-height of doubtful value. Secondly, the head of the specimen is markedly downturned in a very 'Mormyrid' fashion and more so than in any figure or specimen of a Notacanthid that we have seen. Though there is little support for our opinion forthcoming from other specimens of *N. phasganorus* we are satisfied that the X-ray photograph published as Plate 8 and other considerations (dentition+diet, position of operculum in relation to gill-opening) indicate that this may at least be adopted as a natural attitude, even though it may not be the attitude of rest. Accordingly we give two measurements for body-length and other distances from the tip of the snout to various points; the first represents the measurements with the head forced into line with the body, the second with it *in situ*. Statements of body proportions are based on the former to facilitate comparison with other accounts; the corresponding duplicate set may be computed from the data given if desired. Thirdly, there is some doubt regarding the tail, which may have had the tip broken off and subsequently regenerated a caudal fin. In this case it would be necessary to allow about another 5 cm. on the standard length, plus 2–3 cm. for the caudal fin.

Measurements

Total length	970 mm.	(950)
Standard length	945 ,,	(925)
Body:		
Depth at pectoral	140 ,,	
,, pelvics	170 ,,	
,, vent	140 ,,	
Greatest depth	180 ,,	
Greatest breadth	50 ,,	
Length, snout to vent	422 ,,	(402)

Measurements (contd.)

Head:		
Length	122 mm.	
Greatest depth	92 ,,	
Greatest breadth	50 ,,	
Interocular width	25 ,,	
Length of snout	35 ,,	
,, postorbital region	80 ,,	
,, upper jaw	36 ,,	
,, mandible, to hind end of articular	39 ,,	
Breadth of gape	41 ,,	
Length of maxillary spine	6 ,,	
Diameter of eye	21 ,,	
Longest gill-raker	6 ,,	
Dorsal:		
Distance from snout	352 ,,	(350)
Length of base	235 ,,	
Horizontal distance from pelvics	12 ,,	

	I		II		III		IV		V		VI		VII		VIII		IX		X		XI	
Lengths of spines	1		6		7		8		8		9		11		12		10		13		14	mm.
Intervals between spines		6		15		20		21		24		23		22		21		14		11		mm.

Length of soft ray	7 mm.	
Anal:		
Distance from snout	432 ,,	(412)
,, vent	10 ,,	
Length of base	540 ,,	
,, spinous base	230 ,,	
,, first spine	2 ,,	
,, longest spine (XVIII)	19 ,,	
,, ,, soft ray	34 ,,	
Pectoral:		
Distance from snout	148 ,,	(139)
Length, left	65 ,,	
,, right	56 ,,	
Pelvic:		
Distance from snout	350 ,,	(330)
,, base to vent	70 ,,	
,, tip	24 ,,	
Length	46 ,,	
Caudal:		
Distance from tip to dorsal	390 ,,	
Length	25 ,,	

Radial formula D. XI–1; A. XX, 101+; C. 12(?); P. 13; V. III, 7.
Gill-rakers on first arch 3+1+13.
Branchiostegal rays 9.
Vertebrae 185. (Nos. 75 and 80 have double centre.)
(All counts from X-ray photographs.)
Scales along lateral line, about 500.
Scales in transverse series, 31 above lateral line, 58 below.
Pyloric caeca destroyed through decomposition.

Length of the head 7·95 times in the total length; depth at pectoral 6·92; depth at pelvic 5·70; distance from tip of snout to dorsal 2·75; from tip of snout to pectoral 6·55;

from tip of snout to pelvic 2·77; from tip of snout to vent 2·29; tip of snout to anal 2·24; from tip of caudal to dorsal 2·48; base of dorsal 4·12; spinous base of anal 4·21.

Snout 3·48 in head; eye 5·80; postorbital part of head 1·52; upper jaw 3·38; interocular space 4·88; mandible 3·12; pectoral 1·87; pelvic 2·65.

Body elongate, compressed, considerably higher at the pelvics than at the pectorals, even allowing for the distension of the abdomen; the greatest breadth 0·35 the height at the vent; tapering posteriorly into a long slender tail.

Head compressed, shorter than depth of body, 2·46 in the trunk and 3·54 in the length from tip of snout to anal. Snout long, fleshy, 1·4 times the interocular width and 1·66 times the diameter of the eye. Interocular space narrow, strongly convex, 1·19 times the diameter of the eye. Eye covered by semi-transparent skin, lacking an orbital fold. Nostrils close together, much nearer eye than tip of snout, the posterior slit-like, one-third the eye's diameter from the orbit, the anterior opening into a thin-walled tube protected by a small flap. The centres of the eye, of the two nostrils, and the tip of the snout lie on a straight line.

Mouth inferior, broad, gently curved; upper jaw nearly as long as length of snout; maxilla with a posteriorly directed pungent spine on its upper margin, extending to below the middle of the eye. The integument of the mandible forms a labial fold on each side.

Teeth (Pl. 7, fig. 4) in the upper jaw in a single row, 37 on each side, slender, inclining inward, the bases cylindrical, the tips antero-posteriorly flattened and introrse, mesially 3 mm. long, gradating into smaller and simpler lateral ones. Palatines movable vertically with two rows of about 25 rather finer teeth on each side, with sharper markedly introrse tips. Mandible with a complete innermost row of about 30 teeth on each side, resembling those of the upper jaw but more delicate, preceded by two irregular rows of fine aciculate teeth which do not extend as far laterally as those of the main series. All teeth more or less movable. Anteriorly the teeth of the upper jaw bite between the two series of the lower, but owing to the greater radius of curvature the posterior teeth bite outside those of the mandible. The palatine teeth engage with those of the lower jaw. No vomerine teeth.

Gill-openings wide, membranes separate and free from isthmus. Gills four; no pseudobranch visible on superficial examination. Gill-rakers slender, pointed, incurved, well separated, having minute bristles on their inner faces; a little more than half the length of the gill-filaments, the longest 3·50 in the diameter of the eye.

The prominent pores of the lateralis system of the head are distributed thus: 3 in the supra-temporal series, and on each side 5 in the supra-orbital (comprising 2 above the eye, 1 above the posterior nostril, 2 before the anterior nostril), 16 in the infra-orbital and 14 in the preoperculo-mandibular series.

Lateral line gently arched over pectoral, following profile of the back, thence dropping obliquely to one-third the depth of the body over the vent, and further descending nearly to a median position at the point where it disappears two-thirds of the way along the tail. Lateral line pores conspicuous with darkly pigmented lips.

Entire body scaled, even to the lips, except for the hinder margin of the operculum. Scales cycloid, rectangulo-ovate, closely inset in tough sheaths; very small on the head (1·2 × 1·0 to 2·2 × 2·0 mm.), increasing in size posteriorly to a maximum of 4·5×3·7 mm. on the middle of the body, and thereafter becoming progressively reduced until half-way along the tail they equal those of the head.

Pectorals vertically inserted at middle of body-depth, at a distance behind the gill-opening equal to length of own base; bases broad, fleshy, scaled, pedunculate; posterior edge of fin rounded, length slightly more than half length of head.

Pelvics (Pl. 7, fig. 3) closely adjacent, separated by a narrow groove, reaching far short of the vent. Bases fleshy, pedunculate, thickly covered with scales, origin very slightly behind vertical through origin of dorsal, posterior edge rounded. The third pelvic spine has two much smaller ones set against its base, the first of these concealed by skin.

First dorsal spine (Pl. 9, fig. 6) hidden under the skin; last dorsal spine the longest, followed by a recurved soft ray (Pl. 9, fig. 7) set in a fleshy protuberance. There is a slight groove between the bases of the spines and each supports a slight membrane posteriorly which is best developed between the last spine and the soft ray.

The anal commences immediately behind the vent and below the Vth dorsal spine; the XIIIth anal spine lies under the last dorsal. The anal spines are embedded in fleshy tissue (the first completely concealed, Pl. 9, fig. 8), from which successive spines emerge farther and farther.

Caudal (Pl. 9, fig. 9) clearly separated from anal, but lacking a distinct peduncle and probably aberrant owing to regeneration of tip (see p. 75).

Colour. Head and body dark brown, tending to be lighter on the forehead and flanks; lips and hinder edge of operculum bluish-black, fin-rays and anal fin dusky. The fish had a glossy, varnished appearance when dry. Peritoneum and stomach and inside of buccal cavity and operculum black, intestine cream.

COMPARISON WITH SPECIMENS PREVIOUSLY DESCRIBED

The original description of the holotype (Goode, 1881) gives the radial formula D. X; A. XIX (130); C.0; P. (17); V. II, 8–9. Mr. Lachner was asked to re-examine the dorsal, pectoral, and spinous anal fins only, ascertaining whether any concealed spines and rays had been overlooked and whether a count of the pectoral rays obtained by means of an incision across the fleshy base required any modification of the above formula. He finds the right pectoral fin wanting and gives the count for the left: the revised formula now reads:

Holotype: D. X–1; A. XIX, 130; C.0; P. 18; V. II, 8–9.

compared with:

M.C.Z. No. 33946 D. XI–(?); A. XXIV, 127; C. 7; P. 17; V. III, 7.
New specimen, D. XI–1; A. XX, 101+; C. 12(?); P. 13; V. III, 7.

Bigelow & Schroeder give A. XX for M.C.Z. No. 35306. Schroeder, *in lit.*, provides the following additional data:

M.C.Z. No. 35306 P. 16. One soft ray in dorsal.
,, 37027 P. 13. One ,, ,,
,, 37037 P. 16. Two soft rays in dorsal.
,, 33946 Not available for re-examination.

Bearing in mind the known variation in other species we may regard the counts for dorsal, ventral, and spinous anal fins as giving an adequate agreement.[1] The range of variation in the pectoral (13–18) is remarkable, however, even compared with Trotti's counts for *N. bonapartei* (12–14) and Matsubara's for *N. fascidens* (12–15). The discrepancies in the counts given for the caudal in part reflect the curious misunderstanding which has surrounded the problem of the tail structure in this group. The diagnoses of Goode & Bean (1894) contain mutual contradictions:

Fam. Notacanthidae. 'Anal fin . . . extending . . . to the caudal with which it unites.'

Notacanthus. 'No caudal', although under the same generic diagnosis *N. sexspinis* is given a count of C. 5. In the accounts of the various species several numbers are given, including *N. phasganorus* with C.o.

Regan (1929) gives:

Order Heteromi. 'A long tail, with a long anal fin below it, tapering to a point, without caudal fin.'

While the relations of anal and caudal are certainly difficult to ascertain in these fishes and really call for radiographs and alizarin preparations for their proper elucidation, there can be no doubt that many previous descriptions made before the use of the binocular microscope became *de rigueur* will prove to be erroneous when the material is re-examined.

The present specimen shows a distinct separation between the caudal and anal rays, more easily studied in an X-ray photograph (Pl. 9, fig. 9), which shows at least 12 caudal rays. But the structure is markedly different from that of the tails of other species which we have examined, which are symmetrical, having a distinct though small caudal peduncle, already described and figured in *N. phasganorus* by Bigelow & Schroeder (1935). The appearance presented in our figure suggests that the tail has lost its tip at some time and subsequently regenerated a caudal fin.

Since Goode almost certainly included the caudal rays in his count for the anal fin (130) we should do likewise to obtain a comparison, and so have 134 for the fish described by Bigelow & Schroeder and 113+ for the new specimen. A truncation of the tail would also account for this lower number.

Gaimard's (1851) figure of the *La Recherche* specimen evidently represents a tail even more markedly truncated (Vaillant, 1888*b*) and again with a regenerated caudal fin. It seems that this condition is not uncommon in *Notacanthus*.

[1] Vaillant's (1888*b*) data, supplemented by counts from Gaimard's (1851) plate, give the radial formula:

D. XI–1; A. XXII, 92+; C. 8 (?); P. 16; V. III, 8

for the *La Recherche* specimen, which therefore comes within the known range of *N. phasganorus*.

For further comparison the following counts all purport to have been taken on the holotype of *N. nasus* by Bloch (1795), Cuvier & Valenciennes (1831), and Hilgendorf for Goode & Bean (1896) respectively:

D. X; A.+C. XIII, 136; P. 16; V. II, 8.
D. X–O; A. XIII, 116; C. 8; P. 17; V. I, 8.
D. XI; A. XV, 118; C. ?; P. 19; V. III, 7 (l), 8 (r).

There seems to be little useful purpose in attempting to decide the relation between *N. nasus* and *N. phasganorus* on such data, except to remark that the only serious discrepancy, the consistently low count for the spinous anal, must be considered against the range of A. IX–XVIII demonstrated by Trotti (1939) in *N. bonapartei*, and the anterior fin-structure shown in our Pl. 9, fig. 8.